

No. 13.— *Fossil Insects from the Lower Permian of Kansas.*

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DURING the latter part of the summer of 1925, I accompanied Prof. P. E. Raymond on a brief expedition of the Museum of Comparative Zoölogy to the Permian insect deposit in Elmo (Banner Township), Kansas. Up to the present time over 4,000 specimens of insects, representing a fauna quite distinct from that of other Permian beds, have been collected by various students at this locality. Ten orders (Palaeodictyoptera, Protorthoptera, Blattaria, Protodonata, Odonata, Plectoptera, Protohymenoptera, Mecoptera, Copeognatha and Homoptera) have already been recognized by Sellards and Tillyard; Dr. Tillyard, who is working on the Yale collection, has indicated several others which have not yet been described. Most of the specimens collected from these rocks are remarkably well preserved, as shown by the illustrations accompanying Tillyard's descriptions, and by those contained in this paper, and this adds greatly to the value of the fossils, since the period to which the deposit belongs is one of the least understood in the whole geological history of insects. Four of the orders mentioned above are represented by well-preserved specimens in the thirty-three fossils forming the M. C. Z. collection, which although comparatively small is fairly representative.

To Professor Raymond, whose interest and encouragement has made possible this opportunity to work on fossil insects, I am especially grateful; and to the Museum authorities, I am also indebted, both for authorizing the expedition and for the privilege of studying the specimens. Prof. C. T. Brues has made many helpful suggestions, and Dr. R. J. Tillyard, during his recent visit to this country, was kind enough to examine and discuss with me the fossils.

PLECTOPTERA. PROTHEREISMIDAE Handlirsch.

Rev. palaeoz. insekten, 1919, p. 63.

Prottereismephemeridae Sellards, Amer. Journ. Sci., 1906, ser. 4, 23, p. 345.

Twelve species of this family of archaic mayflies have been described by Sellards from the Kansan Permian. They are easily separated from the Ephemeridae by several characters, especially by the presence

of the costal brace, and by the absence of the tornus. Two specimens of the family are in the M. C. Z. collection. One of these (M. C. Z. 2,796, Plate 1, fig. 1), consisting of a basal fragment of a wing, shows the costal brace, but is too incomplete to permit further determination. The other specimen (M. C. Z. 2,785a-b, Plate 1, fig. 2) is a well-preserved apical half of a fore wing, which can almost certainly be referred to Sellards's species *Prottereisma permianum*. The length of the fragment is 10 mm., and the greatest width 5.0 mm. The cross-veins, which were poorly preserved in the Sellards specimen, are very distinct and numerous.

MECOPTERA. PERMOPANORPIDAE Tillyard.

Amer. Journ. sci., 1926, ser. 5, 11, p. 139.

Wings similar in general shape to those of living Panorpidae and Choristidae, but smaller; subcosta variable in length and in form of ending; R_1 strong, passing through the pterostigma, and with or without distal veinlets extending to the costa; radial sector with from four to nine dichotomously arranged branches; media with from five to eight branches, also dichotomous; Cu_1 straight and strong, terminating near the middle of the posterior margin; cubitomedian Y-vein well developed; Cu_2 straight, weak, concaved; two or three anal veins, usually simple.

PERMOPANORPA Tillyard.

Amer. Journ. sci., 1926, ser. 5, 11, p. 143.

Wings of variable width basally; apex well rounded; pterostigma well developed; subcosta simple or forked, terminating in the costa; R_1 usually with at least one pterostigmatic veinlet; R_s with from five to nine branches; media with six distinct branches; cubitomedian Y-vein with its branches variable.

PERMOPANORPA RAYMONDI, sp. nov.

Plate 1, fig. 3, 4. Plate 3, fig. 1.

TYPE.—M. C. Z. 2,795. Kansas: Elmo.

Fore wing:—length of fragment 3 mm.; estimated length of whole wing about 6 mm.; greatest width 1.9 mm.; pterostigma 1.4 mm.; Sc joined to R_1 by an oblique cross-vein; R_1 with four costal veinlets, the first passing along the basal border of the pterostigma, and the other three extending through the pterostigma; R_s with seven branches; R_2 forked; R_{2a} and R_{2b} turned upward

at their tips; R_3 and R_4 simple; R_5 deeply forked, with the posterior member again divided at a point midway between its origin and termination; R_{5b1} joined basally to R_{5a} by an oblique cross-vein; R_{5b} also joined by two cross-veins to the media; M_1 forked to half its length; M_{1b} joined to M_{2a} by a cross-vein; M_2 forked even more deeply, with the anterior branch of the fork bifurcate in the type specimen, probably an individual characteristic; M_{3+4} dividing somewhat before the division of M_{1+2} ; M_2 joined to M_3 by a stout cross-vein, and M_{3+4} united to Cu_1 by a longer cross-vein. Unfortunately, the margin of the rock passes through the middle of the wing, so that the basal half is missing. The hind wing was apparently folded and creased, only the front portion being clear. The part of this wing that is distinct is similar to that of the fore wing: the pterostigma has about the same shape, size, and position; and R_1 and R_2 are developed as in the fore wing. The characteristics of the remaining veins are obscured by the hind margin, which has apparently folded over the middle of the wing.

The part of this specimen that was secured is beautifully preserved, the veins appearing as dark brown lines, in contrast to the light color of the rock in which the insect was imbedded. The sockets of the macrotrichia are very distinct on all of the longitudinal veins, and in some places the entire hair is evident. This is especially true of the veins of the hind wing, where the trichia are 80 microns long. The hairs on the pterostigma are slightly longer, being 90 microns long. The margin of the wing is bordered by a fringe of finer hairs, 56 microns long, such a fringe as this being present on the wings of the living *Panorpa*.

Besides the wings there are also two fragments of legs. One of these is very small, but the other is a whole joint, and, judging from the presence of a terminal spur, is a tibia. This joint (Plate 3, fig. 1A) is 1 mm. long; the spur .2 mm. long; and the hairs which cover the fragment are 140 microns long. It is indeed unfortunate that the rock containing the specimen fractured in such a way that the body and left wings of the insect could not be secured.

This species is the eighth to be described within *Permopanorpa*. The venation of *P. raymondi* combines many characteristics of the veins of several other species, but appears, in all cases, to have distinguishing features. Its venation is very close to that of *P. tenuis* Tillyard,¹ but differs mainly in the possession of a deep fork on R_{5b} , and

¹To avoid confusion it should be noted that the figures of *P. tenuis* Tillyard and *P. inaequalis* Tillyard are incorrectly named in Dr. Tillyard's paper (Amer. Journ. Sci., 5, 11, p. 146-147). Figure 8 is *P. tenuis*, and Figure 9 is *P. inaequalis*, and the descriptive titles under these figures should be interchanged. The references in the descriptions are also reversed.

in the position of the pterostigma, which in *P. tenuis* begins quite a distance beyond the first costal veinlet of R_1 . Because of this similarity, I have added, in dotted lines and somewhat diagrammatically, the basal halves of the veins of *P. tenuis* to the figure of *P. raymondi*, merely to indicate a possible origin of the veins. This new species is also similar to *P. inaequalis* Tillyard, but is readily separated by the shape of the wing, the position of the pterostigma, and by the possession of a simple R_4 , and a branched R_5 . It also resembles *P. schucherti* Tillyard to a striking degree, but is distinguished by the great difference in the number of cross-veins, by the division of R_{5b} , and by the upward turning of R_2 and R_3 .

COPEOGNATHA. PSOCIDIIDAE Tillyard.

Amer. journ. sci., 1926, ser. 5, 11, p. 319.

Fore wing:—comparatively long and narrow, the breadth being between one third to one fourth the wing-length; subcosta either entirely free or fused basally with R, usually terminating on R_1 ; area between R_1 and R_s usually without a cross-vein, occasionally one present; median cell open; areola postica flattened, two to three times as long as high, and not connected with the media by a cross-vein.

DICHENTOMUM Tillyard.

Amer. journ. sci., 1926, ser. 5, 11, p. 320.

Fore wing:—Sc distally forked, terminating at about half the length of the wing; R_1 with a pterostigmatic area between R_{1a} and R_{1b} ; R_s arising at a point on the radius about one fifth the length of the wing from the base, and continuing nearly straight up to the well-developed distal fork; basal portions of M, Cu, and R distinct, but lightly chitinized; 1A close to Cu, but diverging distally; 2A remote from 1A basally, but converging distally; cross-veins apparently absent.

DICHENTOMUM complexum, sp. nov.

Plate 2, fig. 1. Plate 3, fig. 2.

TYPE.—M. C. Z. 2,792. Kansas: Elmo.

Length of wing 4.5 mm.; greatest width 1.5 mm.; pterostigma short and weakly developed; Sc quite remote from the costal margin, and terminating on R_1 ; R straight at the base but soon bending upward toward the anterior margin; R_s curved slightly backward just beyond its origin, terminating in a broad distal fork; M weakly chitinized, and apparently free from R at the base;

Rs distally forking to very nearly the same depth as M; M_{1+2} and M_{3+4} separating quite a distance beyond the origin of Rs; M_{3+4} with a narrow fork; Cu_1 with a very wide fork; Cu_{1a} twice as long as Cu_{1b} , and curving slightly upward just beyond its origin; Cu_2 joining Cu_1 at the very base of the wing; Cu_2 , 1A, and 2A distributed as indicated in the generic description.

This is the second specimen and species known in the genus, the other being *D. tinctum* Tillyard. These two species can be distinguished as follows:—

1. Pterostigma elongate, well developed; M_{1+2} forked much more deeply than Rs..... *tinctum*
2. Pterostigma roundly oval, weakly developed; Rs and M_{1+2} forked to nearly an equal depth..... *complexum*

PROTORTHOPTERA.

The Protorthoptera are the dominant insects of the Elmo limestone, but they represent an entirely different division of the group from those taken in other localities and horizons. In general they are smaller, some having wings only 4.5 mm. long. Their wing-venation is comparatively specialized, usually reduced, so that there is some doubt as to the true position of these insects. In many cases the reduction has progressed so far that the venation simulates that of some living insects, particularly neuropteroids. A study of a large collection of these specialized forms may indicate that they are only closely related to the Protorthoptera, and not actually within the order. Unfortunately, the M. C. Z. collection contains only isolated wings. It is worth noting that all these specimens are fore wings, and this is interesting since the fore wing is usually the part best preserved in all described Protorthoptera, and often the only structure by which a species is known. This would seem to indicate, as has often been assumed, that the fore wing of the members of this order was heavier or stronger, though still membranous, than the hind wing, and hence more capable of preservation; in two families (Lepiidae and Probnisidae) from the Kansan Permian, however, the fore wing was distinctly coriaceous.

Because of the excellent preservation of the Kansan material, the Protorthoptera obtained there have thrown light upon the nature of the wing-surface of this order of insects. Sellards has mentioned minute scales on the wing-membrane of genus Lemmatophora, but since no photograph of such a wing accompanies the description, and the

scales are not further mentioned, the exact nature of this wing-structure is obscure. Sellards also noted a few hairs on the costal border of the fore wing of *Lemmatophora horsinuta*. Four of the protorthopterans (M. C. Z. 2,786a-b, 2,790b, 2,791a, 2,794) have hairs preserved on the wings. In one specimen (M. C. Z. 2,786b) these hairs are so clear that even the points are discernible. A few large hairs, 60-70 microns long (probably comparable to macrotrichia), are confined to the basal half of the subcosta, being completely absent from the membrane and the remainder of the veins. Minute hairs, 30-40 microns long, are densely distributed over the entire wing-surface.

LEMMATOPHORIDAE Sellards.

Amer. Journ. sci., 1909, ser. 4, 27, p. 162. Handlirsch, Rev. palaeoz. insekten, 1919, p. 43.

The following characters were assigned to this group:—

Wings membranous, as long as the abdomen; pronotum with a membranous expanse; subcosta simple, terminating near or beyond the middle of the wing on the costal border; radial sector simple to four-branched; cubitus one- to three-branched; Cu_2 simple; anal furrow distinct and the area containing one or two strong veins; cross-veins strong, but not numerous.

Handlirsch places the forms with these characters, together with others from the same locality, in an order which he calls "Protorthoptera vel Protoblattoidea." However, an examination of their venation indicates that the veins were developed along quite different lines from those of the protoblattids, where the longitudinal veins tend to concentrate along the axis of the wing. If the lemmatophorids, as represented by such a type as *Estadia*, are to be removed from the Protorthoptera, their closest affinities are not with the Protoblattoidea.

The Lemmatophoridae include seven genera, which may be distinguished as follows:—

1. Cu_1 forked *Lectrum*
1. Cu_1 simple 2.
2. Radial sector fused to M_1 ; M_2 branched 3.
3. Both Cu_1 and Cu_2 simple *Prosaites*
3. Cu_1 branched 4.
4. Radial sector bifurcate *Estadia*
4. Radial sector simple 5.
5. Subcosta close to anterior border; radial sector fused to M_1 before middle of wing *Paraprisca*

- 5. Subcosta remote from anterior border; radial sector fused to M_1 beyond middle of wing. *Lisca*
- 2. Radial sector free from M_1 ; M_2 simple or branched. 6.
 - 6. Radial sector simple. *Lemmatophora*
 - 6. Radial sector forked; radius bifurcate. *Artinska*

ESTADIA Sellards.

Amer. Journ. sci., 1909, ser. 4, 27, p. 166.

Front wings elongate; subcosta arched at the base and extending two thirds of the wing-length; radial sector arising 3 or 4 mm. from the base, fusing for a short distance with M_1 ; media dividing before origin of sector; Cu_1 bifurcate; two anal veins.

ESTADIA TRIPUNCTATA, sp. nov.

Plate 2, fig. 2-4. Plate 3, fig. 3.

TYPE.—M. C. Z. 2,786a, b. Kansas: Elmo.

Length of wing 9 mm.; greatest width 5 mm.; costal and hind margins curved, apex well rounded; radial sector with its anterior branch forked at its tip, and the posterior branch simple; M_1 and M_2 forked, but M_2 more deeply.

This wing is so perfectly preserved that the coloration is still evident, showing three well-defined pigment patches: one near the center of the wing, just beyond the fusion of R_s and M ; another at the base, between R and M ; and a third between Cu_1 and Cu_2 . The micro- and macrotrichia are also preserved. The microtrichia, 30-40 microns long, are distributed over the whole wing surface; but the macrotrichia, 60-70 microns long, are confined to the basal half of the subcosta.

The four described species of this genus can be distinguished as follows:—

- 1. Radial sector fused with M_1 for a distance of 1 mm. *elongata*
- 1. Radial sector fused with M_1 for a distance of not more than 0.5 mm. 2.
- 2. M_1 simple. *tenuis*
- 2. M_1 forked. 3.
- 3. Radial sector fused with M_1 for a distance of 0.5 mm. M_{1+2} with a shallow fork. *arcuata*
- 3. Radial sector fused with M_1 for a distance not greater than 0.1 mm., so that the two veins appear to cross, rather than fuse. M_{1+2} with a deep fork. *tripunctata*

The order Protorthoptera is also represented in the collection by a number of other fossils, which are not so well preserved as the preceding. One of these (M. C. Z. 2,793) is *Probnis speciosa* Sellards. Two species of Artinska (M. C. Z. 2,789, and M. C. Z. 2,790a-b), one species of Lemmatophora (M. C. Z. 2,788a-b), and one species of Stemma (M. C. Z. 2,791a-b) also represent the order, all of these apparently being new species; but since the study of the Protorthoptera in the large Yale collection has not yet been completed, it seems wiser to wait for these new species to be described from this latter collection, which may contain better specimens of the same forms, rather than to attempt a classification based upon inadequate material.

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